NUI Galway
OÉ Gaillimh

Semester 1 Examinations 2014/ 2015

Exam Code(s)	4BCT, 3BA, 1SD, 1MDM
Exam(s)	4th Year B.Sc. (CS&IT) 3rd Year B.A. (Information Technology) Higher Diploma in Applied Science (Software Design & Development) Masters in Digital Media
Module Code(s)	CT404, CT336
Module(s)	Graphics and Image Processing
Paper No.	
Repeat Paper	
External Examiner(s)	Prof. L. Maguire Dr. J. Power
Internal Examiner(s)	Prof. G. Lyons Dr. M. Madden * Dr. S. Redfern
Instructions:	Answer any three questions. All questions carry equal marks.
Duration	2 hours
No. of Pages	5
Discipline(s)	Information Technology
Course Co-ordinator(s)	

Requirements:

MCQ	Release to Library:	Yes	X	No
Handout				
Statistical/ Log Tables				
Cambridge Tables				
Graph Paper				
Log Graph Paper				
Other Materials				
Graphic material in colour	Yes	X	No	

PTO

Q.1. (Graphics)

(i) In computer graphics, the transformations that may be applied to a coordinate system are: translation, rotation, and scaling. Explain, using a diagram, why the order in which multiple transformations are combined can affect the final result. Use Canvas/Javascript or X3D code to illustrate your answer. [8]

(ii) Consider the Canvas/Javascript code shown below, which draws a purple rectangle, size 50x50 pixels onto a Canvas of size 600x600 pixels.

Explain the use of the following three lines of code: [6]

```
context.translate(x,y);
context.restore();
window.setTimeout("draw();",1000/30);
```

(iii) Modify the code so that the purple rectangle moves across the Canvas at a fixed rate. Ensure that it changes direction when it hits the edge of the Canvas, rather than disappearing off-screen. [6]

```
<html>
 <head>
  <script>

var x=200, y=200;

function draw() {
  var canvas = document.getElementById("canvas");
  var context = canvas.getContext('2d');

  context.save();

  // over-write previous content, with a grey rectangle
  context.fillStyle="#DDDDDD";
  context.fillRect(0,0,600,600);

  context.translate(x,y);

  // draw a purple rectangle, size 50,50
  context.fillStyle="#CC00FF";
  context.fillRect(0,0,50,50);

  context.restore();

  window.setTimeout("draw();",1000/30);
}
  </script>
 </head>

 <body onload="draw();">
   <canvas id="canvas" width="600" height="600"></canvas>
 </body>
</html>
```

Q.2. (Graphics)

(i) Describe the use of extrusion in X3D, referring to each of the seven fields used by the Extrusion node. Note that extrusion and other useful nodes from the X3D language are summarised on the final page of this exam paper. [5]

(ii) Write X3D code to make the 3D model of the bar-stool illustrated in Fig 1.

Include a diagram of your model showing its measurements, and make the model as geometrically accurate as possible [6]

Define Materials for the model: the base part of the stool should have a shiny grey material, and the upper part should have a shiny black material [5]

Fig 1: 3D model of a bar-stool

(iii) In realtime 3D graphics, what are billboards, and how do they assist in the efficient rendering of an animated scene? [4]

Q.3. (Graphics)

(i) What are surface normals? Why are they essential to surface shading and hidden surface removal algorithms? Use diagrams to illustrate your answer. [4]

(ii) In 3D graphics, what purpose do visibility culling techniques have? [2]
Explain the operation of the following visibility culling techniques, using a diagram in each case to illustrate your answer: frustum culling, back-face culling [4]

(iii) With respect to 3D graphics rendering, define the terms: specular colour, diffuse colour, ambient lighting. Illustrate each term with a diagram. [6]

(iv) In 3D graphics, what is the purpose of normal mapping? Explain how a normal map might be generated as part of the 3D modelling process, and explain technically how the normal map is used at run-time. [4]

Q.4. (Image Processing)

(i) The first steps in many image processing algorithms often include blurring and edge enhancement. With reference to the noisy image below (Fig 2), explain how blurring and edge enhancement could assist with the extraction of the circles and oval from the image. [5]

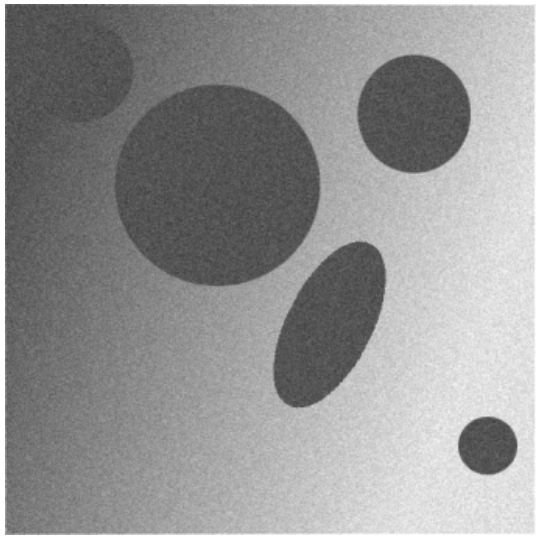

Fig 2

(ii) Describe, with use of a diagram, the convolution algorithm which is commonly used for both blurring and edge enhancement. Present a convolution kernel suitable for edge detection, and explain how this kernel produces the desired result, assuming a greyscale image with pixel values in the range 0 to 255. [7]

(iii) The Hough Transform (HT) is an image processing technique that detects simple geometric shapes in edge-enhanced images. Outline the HT algorithm for detecting circles, and sketch the results you might expect when this algorithm is applied to an edge-enhanced version of Fig 2. How might you algorithmically detect the oval shape, given data output from the HT for circles? [8]

Q.5. (Image Processing)

(i) Describe the morphological image processing techniques of erosion and dilation. Compare the four operations (i) opening, (ii) closing, (iii) thinning and (iv) thickening. For each of these 4 techniques, describe one situation where it would provide useful results. [10]

(ii) Consider the image of a bubble, shown in Fig. 3

The image contains substantial amounts of noise, and there exists a large section of bright 'shine' pixels across the centre of the bubble. Propose and justify a series of image processing steps that would be suitable to accurately measure the number of pixels inside the bubble. [10]

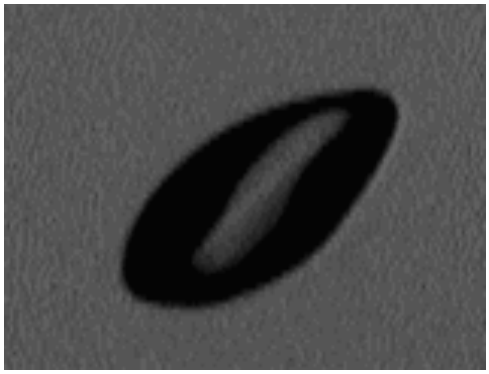

Fig. 3

Some useful X3D nodes:

Node	Important Fields and Nested Nodes
Shape	Nested Nodes: Appearance, Geometry Nodes (Box, Sphere, Cone, Cylinder, Text, Extrusion, etc.)
Appearance	Nested Nodes: Material, ImageTexture
Material	Fields: diffuseColor, specularColor, emissiveColor, ambientIntensity, transparency, shininess
ImageTexture	Fields: url
Transform	Fields: translation, rotation, scale, center. Nested Nodes: Other Transforms, Shapes, Sensors
TimeSensor	Fields: enabled, startTime, stopTime, cycleInterval, loop
PositionInterpolator	Fields: key, keyValue
OrientationInterpolator	Fields: key, keyValue
Extrusion	Fields: crossSection, spine, scale, orientation, beginCap, endCap, creaseAngle
Box	Fields: size
Sphere	Fields: radius
Cylinder	Fields: radius, height, side, top, bottom
Cone	Fields: height, bottomRadius, side, bottom
PointLight	Fields: on, location, radius, intensity, ambientIntensity, color, attenuation
ROUTE	Fields: fromNode, fromField, toNode, toField

Some useful methods/properties of the Canvas 2D Context object:

Method/Property	Arguments/Values	Notes
fillRect	(Left, Top, Width, Height)	Draw a filled rectangle
beginPath	None	Start a stroked path
moveTo	(X, Y)	Move the graphics cursor
lineTo	(X, Y)	Draw a line from graphics cursor
stroke	None	End a stroked path
fillStyle	="rgb(R,G,B)"	Set fill colour
strokeStyle	="rgb(R,G,B)"	Set line colour
save	None	Save the current coordinate system
restore	None	Restore the last saved coord system
translate	(X,Y)	Translate the coordinate system
rotate	(angle)	Rotate the coordinate system clockwise, with angle in radians
scale	(X,Y)	Scale the coordinate system independently on the X and Y axes